December 12–15, 2011
NEW ORLEANS, LOUISIANA

2011 National Weatherization
Training Conference

Weatherization Works

Next-Generation Multifamily National Energy Audit Tools

– Jennifer Somers, DOE
– Mini Malhotra and Michael MacDonald, ORNL
– Norm Bourassa and Evan Mills, LBNL

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Framework for Sustainability

Professional Workers/ Quality Work

Training and Certification of Workers

Defining Worker Tasks

Creating Work Specifications

Market Expansion

- Multifamily
Energy Audit Tool
Standard Work Specifications
Weatherization Innovation Pilot Program

- Private Market Integration
Better Buildings
Building America
Energy Star

- Healthy Homes
Wx Plus Health

- Regulatory Changes Under Consideration
Grant to Loan
Appendix A

- National Evaluation
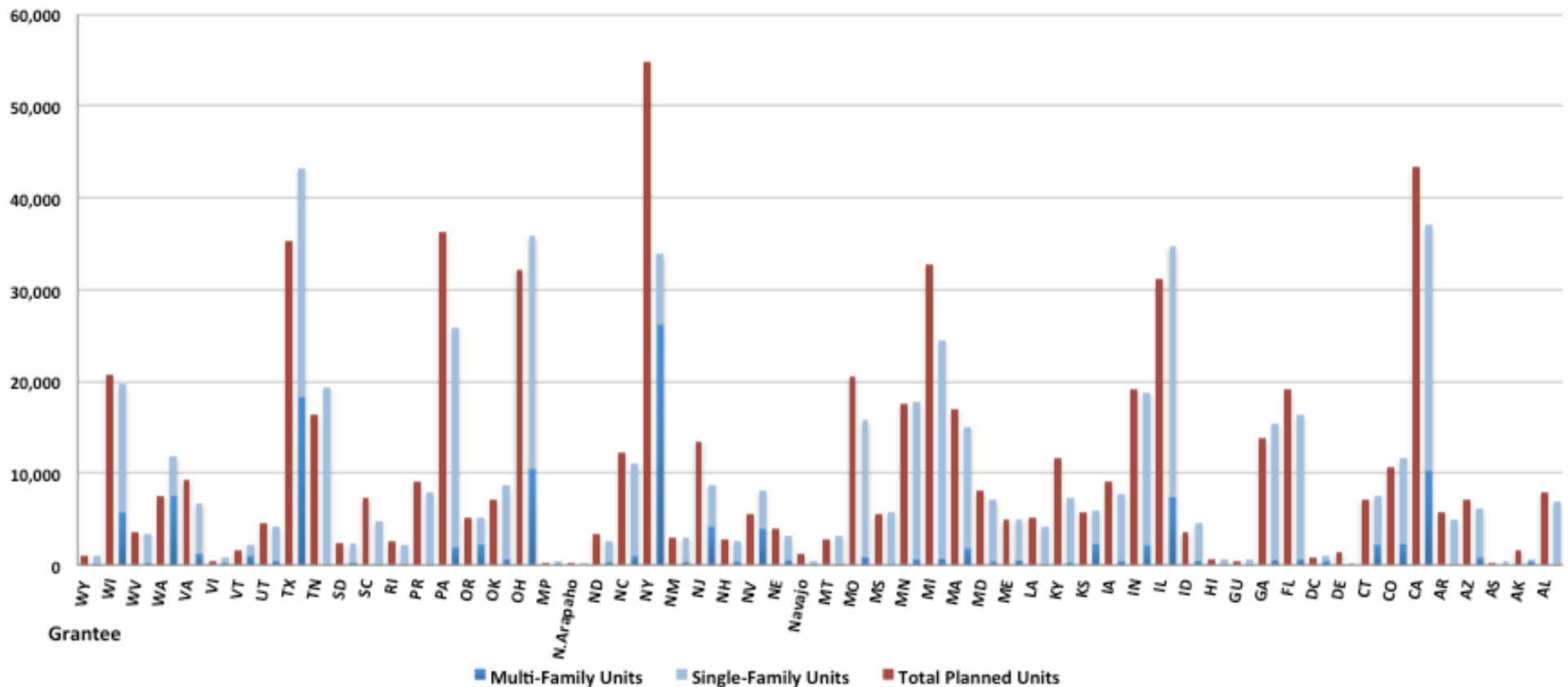Non Energy Benefits Study

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Multi/Single-Family Unit Weatherization
(Total Completed vs. Total Planned)

Grantee

■ Multi-Family Units   ■ Single-Family Units   ■ Total Planned Units

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Guidelines for Home Energy Professionals: Putting Experience on Paper

This project leverages all of the WAP's experience and leadership to create a set of tools to benefit the entire Home Performance Industry.

- Building Science Experts

- Home Performance Training Specialists

- Industry Partners

- National Laboratories

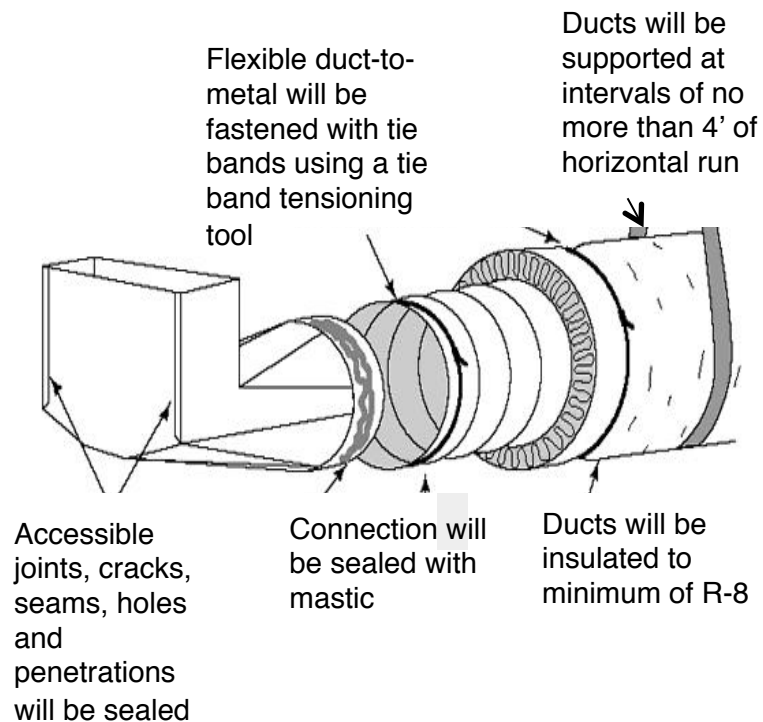U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

QUALITY WORK

QUALIFIED WORKFORCE

Standard Work Specifications

Flexible duct-to-metal will be fastened with tie bands using a tie band tensioning tool

Ducts will be supported at intervals of no more than 4' of horizontal run

Accessible joints, cracks, seams, holes and penetrations will be sealed

Connection will be sealed with mastic

Ducts will be insulated to minimum of R-8

Reference Technical Standards

Accreditation of Training Programs

Wx Training Center

Certification of Workers
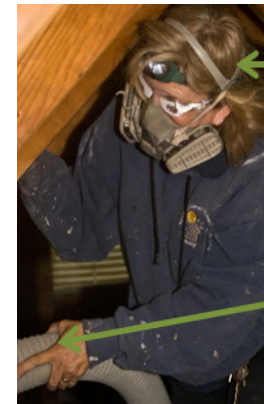
Knowledge, Skills, Abilities

Job Task Analysis

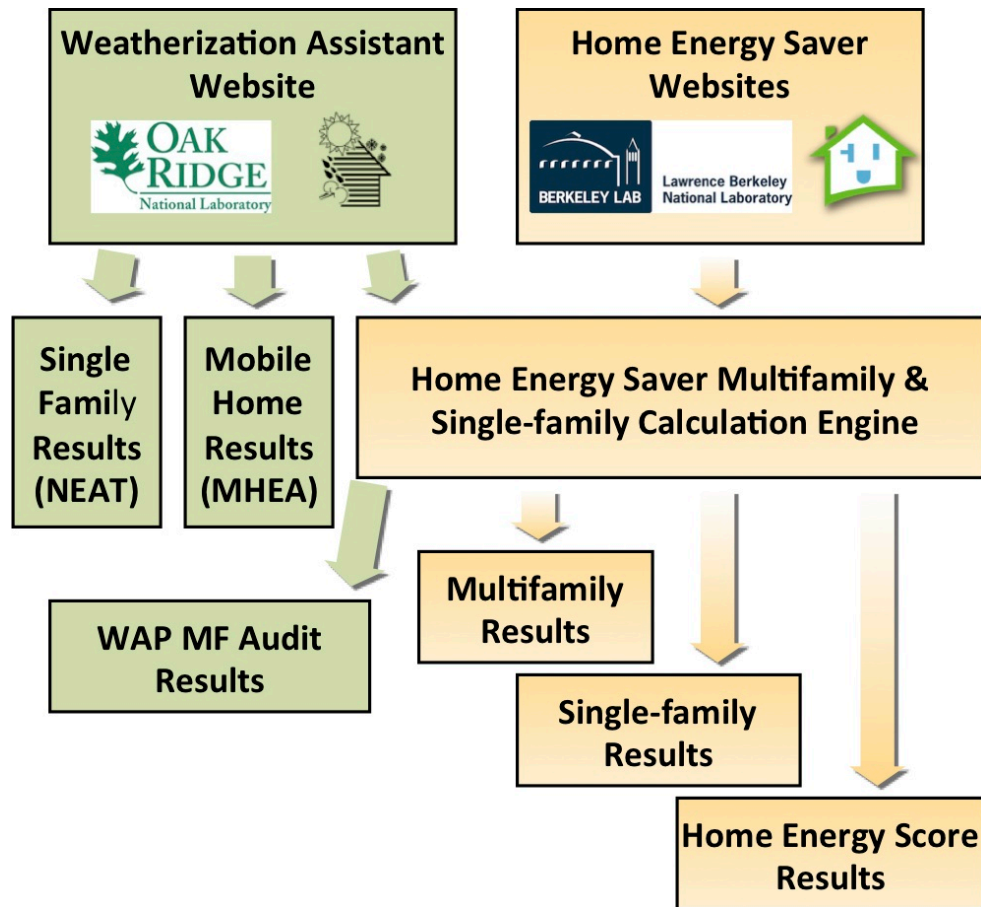U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

Multi-Family Audit Tool: ORNL and LBL Collaboration

Major Energy Audit Tool Feature	Responsible Lab
DOE-2 macro BDL coding	ORNL, LBNL
HES API for multifamily	LBNL
Weatherization Assistant web interaction with API's	ORNL
HES back-end components	LBNL
Weatherization back end components	ORNL
Multifamily user interface	ORNL

Weatherization Assistant Website — OAK RIDGE National Laboratory

Home Energy Saver Websites — BERKELEY LAB Lawrence Berkeley National Laboratory

Single Family Results (NEAT)

Mobile Home Results (MHEA)

Home Energy Saver Multifamily & Single-family Calculation Engine

WAP MF Audit Results

Multifamily Results

Single-family Results

Home Energy Score Results

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Relation of Audit Tools and Standard Work Specification

Data Gathering
Systematic inspection of all building systems via a prescribed protocol

⬇

Analysis and Work Order
Analysis of data for energy savings opportunity, cost effectiveness and health and safety concerns

⬇

Work
Installation of measures called for in the work order

⬇

Inspection/Reporting
Post installation verification that work has been ordered and completed to national standards

Audit Software

The Audit Tools assist the auditor in the analysis and decision making process. The analyze energy usage, make recommendations for retrofit measures and assist in developing the work order.

Standard Work Specifications

The Standard Work Specifications define the minimum requirements for effectively completing the work. They are used to develop job-site manuals and as the criteria for post-work inspection.

Core Team

- DOE/WAP
  - Jennifer Somers and Josh Olsen
- ORNL (9 people)
  - Mark Ternes (Principal Investigator)
  - Mini Malhotra, Michael MacDonald (SRA), Piljae Im, Gina Accawi
  - Software development: 2 ORNL staff and 2 subcontractors
- LBNL (10 people)
  - Evan Mills (Principal Investigator)
  - Norm Bourassa (Technical Lead)
  - Leo Rainer, Chris Havstad, Gregory Homan, Danny Parker (FSEC), Sub-contractors (coding, testing, & usability)

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Multifamily Audit Tools Project Goals

Assess market needs for next-generation multifamily energy analysis within the WAP and beyond and create the next generation of software tools to serve that need.

- Enhance energy modeling capabilities
- Provide flexible multi-zone, multi-system modeling environment
- Improve retrofit measure identification
- Enhance auditor capabilities
- Allow improved workforce skills & mobility
- Build confidence among consumers, building owners, financing community

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Proposed Timeline

Release dates ★
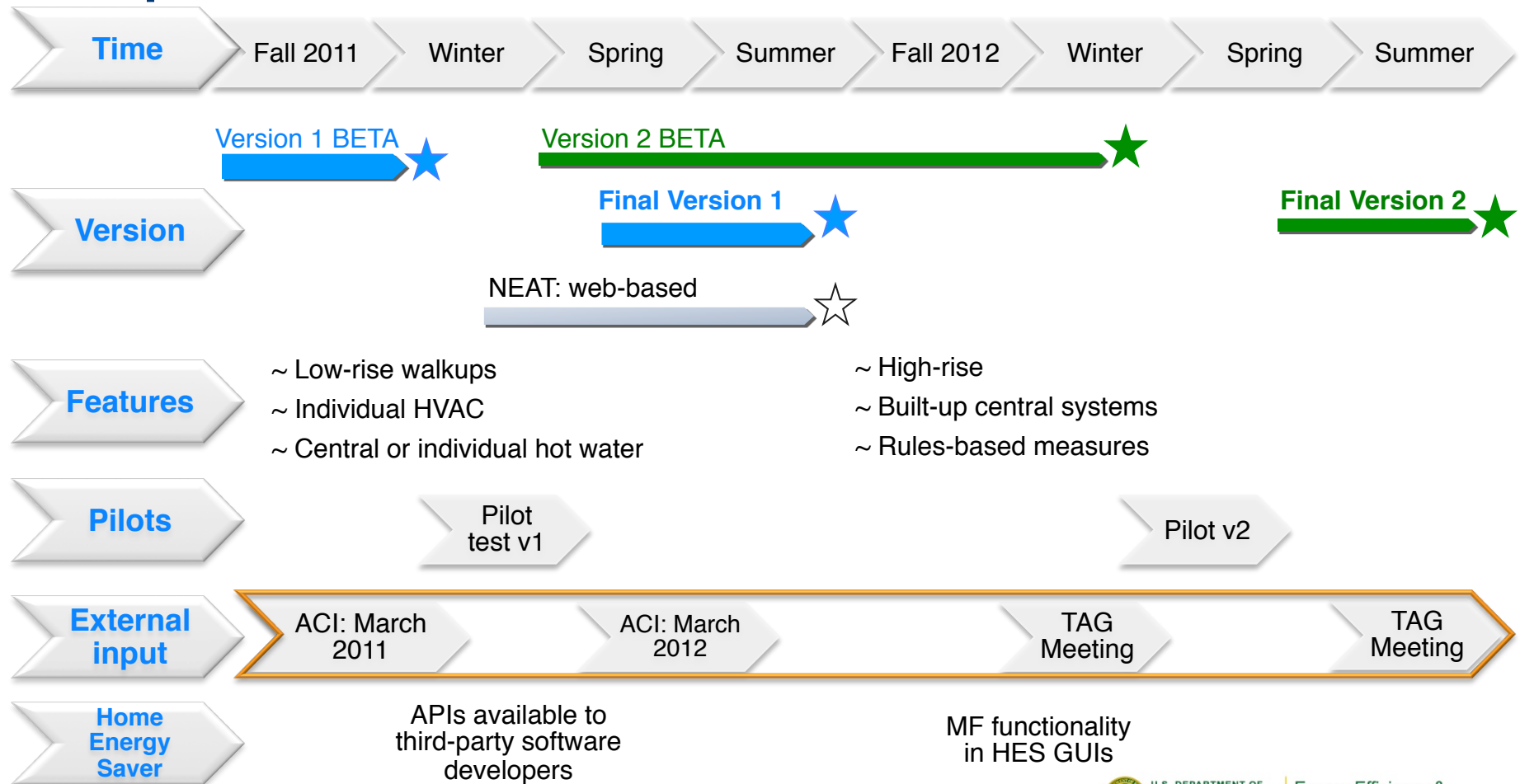
Time	Fall 2011	Winter	Spring	Summer	Fall 2012	Winter	Spring	Summer

Version

Version 1 BETA ★

Version 2 BETA ★

Final Version 1 ★

Final Version 2 ★

NEAT: web-based ☆

Features

~ Low-rise walkups
~ Individual HVAC
~ Central or individual hot water

~ High-rise
~ Built-up central systems
~ Rules-based measures

Pilots

Pilot test v1

Pilot v2

External input

ACI: March 2011

ACI: March 2012

TAG Meeting

TAG Meeting

Home Energy Saver

APIs available to third-party software developers

MF functionality in HES GUIs

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Existing Multifamily Tools: WAP

- EA-QUIP, TREAT, NEAT, others have approvals

- Requests for approval of eQUEST

- Special tools or analyses to "verify" results

- Tools vary in their strengths and weaknesses (climates, system types, building types and complexity, ability to evaluate measures)

- Some disk-based, others usable via the web

- Some tools free, others require license

Details on Some Existing Tools

	eQUEST	EA-QUIP	TREAT-MF	NEAT
WAP usability	Case-by-case	Large MF	Small & large MF	Small MF
Calculation	DOE 2.2 (hourly simulation)	CIRA (variable-base degree-days)	SUNREL (thermal network)	CIRA (variable-base degree-days)
Developer	James J. Hirsh & Associates	AEA (CIRA by LBNL)	PSD Consulting (SUNREL by NREL)	WAP/ORNL (CIRA by LBNL)
Flexibility	Multiple zones Multiple systems	Single-zone Central systems No cooling	Multiple zones Multiple systems Limited measures Heating climates	Single-zone Multiple systems
Utilities input	Not available	Required	Required	Optional
Cost	Free	License fee	License fee	Free
Availability	PC	Web	Web	Desktop

Assessing User Needs; Incorporating User Input

- Building stock review

- Two focus groups - Fall 2010

    - 15 – 20 participants in each session from all over country

- Discussion sessions at ACI and presentation in Chicago

    - ~40 attendees at ACI

    - ~50 attendees at Chicago presentation in August

- Social Media (Home Energy Pros) - ongoing

    - 77 members in discussion, 4 topical threads, 40 posts

>> Affirmation of desire for improved energy analysis tools

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Important That Tools Address Low Rise and Hot Climates

RECS 2005 MF 5+ Regional Breakout
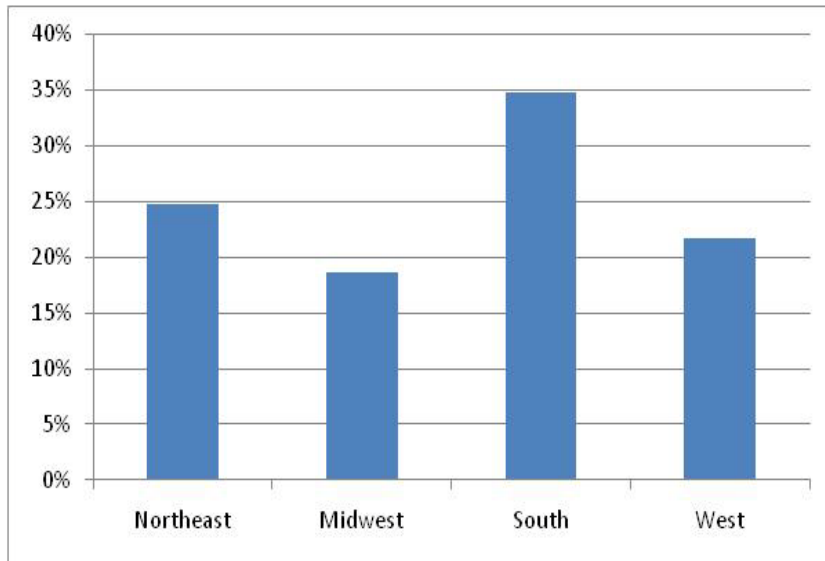
Heating System Regional Breakout
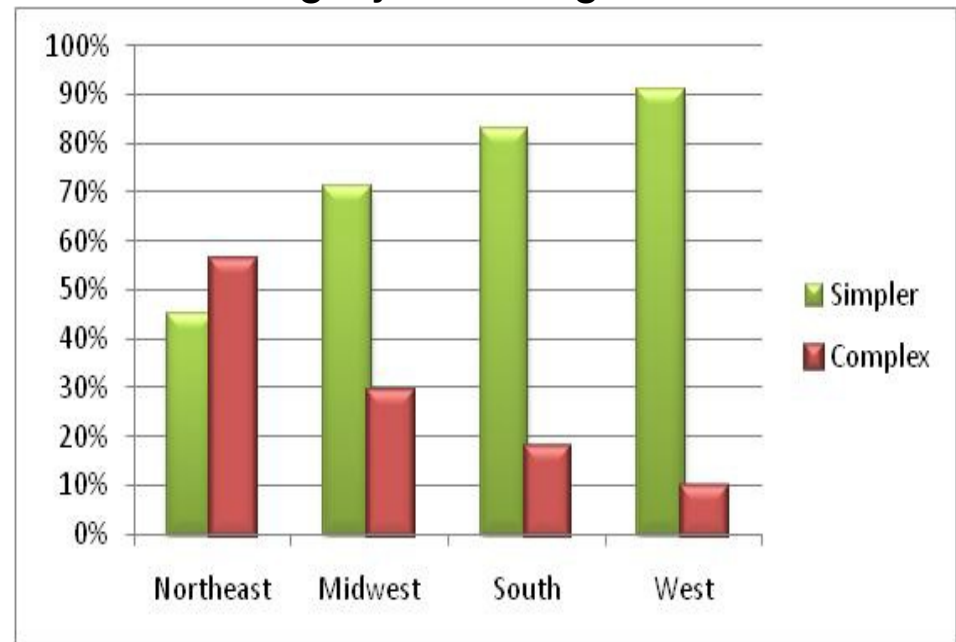
- RECS 2005, about 17 million households
- 70–80% of all MF 5+ dwellings are in "small" buildings in all four regions
- Complex systems less important in S and W

Some Primary Needs Identified

- Technical
    - Multiple zones and heating & cooling systems
    - Improved methods of handling thermal distribution systems
    - Improved methods of handling impact of sensor location, controls, operation
    - Better handling of ventilation systems and measures
    - System degradation and tune-up/maintenance measures
    - Rules-based savings estimation
    - Water-mains temperature effect on DHW energy use
    - Utility bill disaggregation, with improved weather data
- Market
    - A large proportion of the target building stock is low-rise and in hot climates
    - Web-based delivery preferred over disk-based
    - Web services (APIs) desired by third-party tool developers
    - Users seek tools to perform analysis within as well as outside the WAP framework

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Weatherization Assistant — today
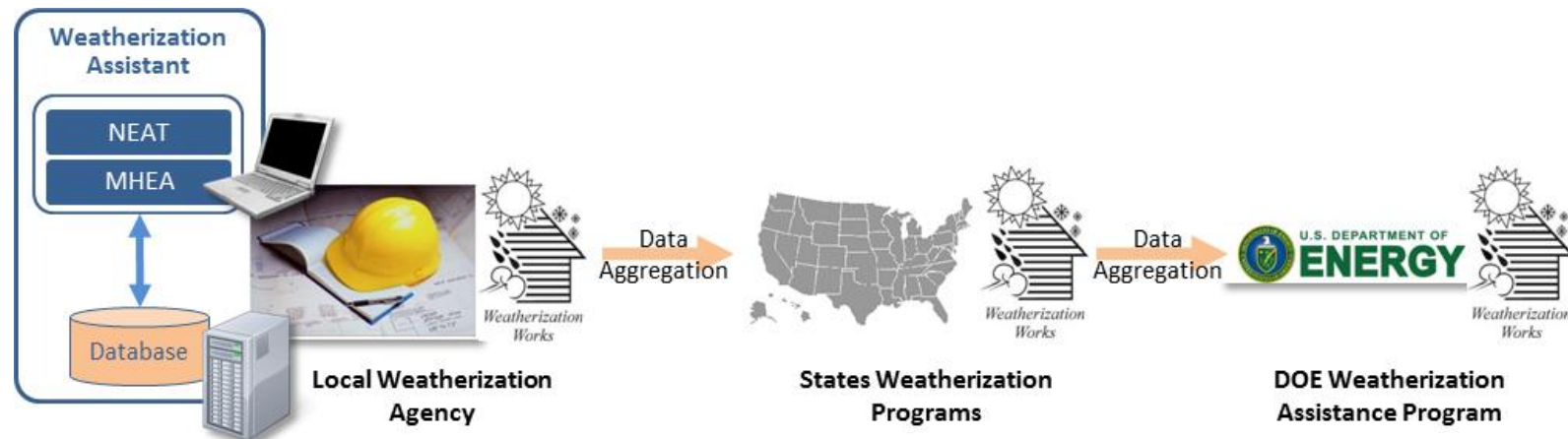
- NEAT and MHEA only — not multifamily-specific
- Locally run on PCs at agency level
- Aggregation to state level by agency

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Weatherization Assistant — planned
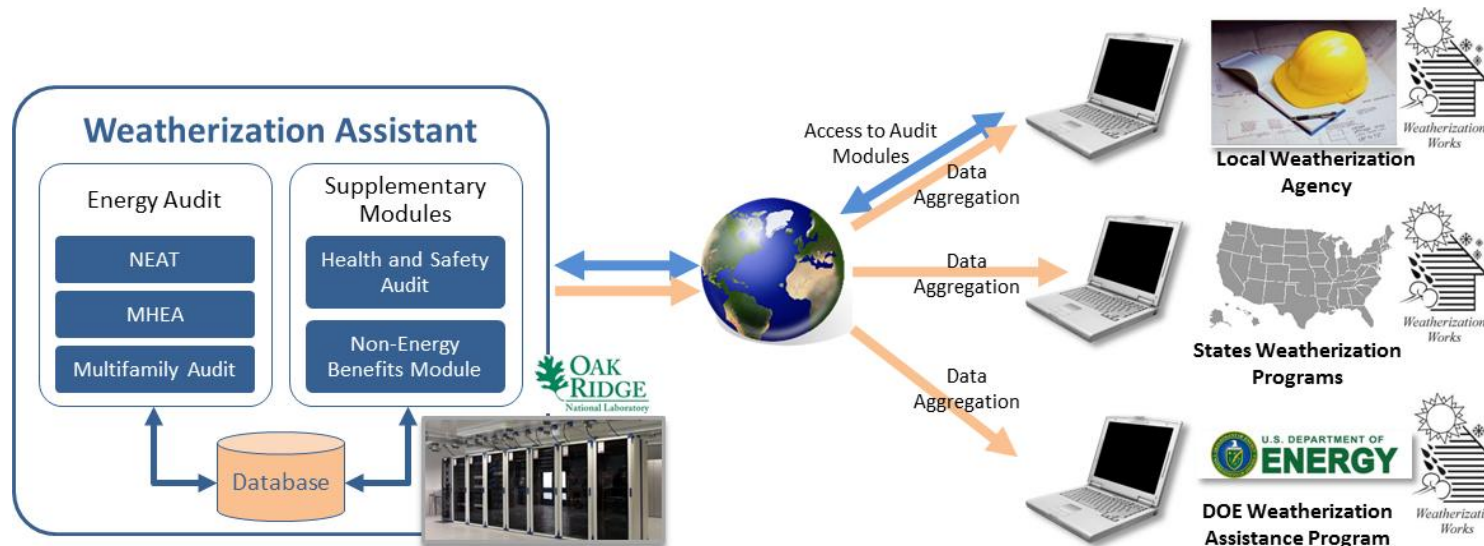
- NEAT, MHEA, H&S, NEBs, new multifamily tool
- All run as Internet web service, secure servers
- Central data base

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Retrofit Measures, Version 1

Measure	Coverage
Air sealing	Basic only, all combined in air change or other model
Insulation / R-value	Add or augment in any envelope component
Windows	Replace, add storms, add interior shading
Doors	Replace, add storm door
Heating system	Replace, IID, tuneup—specify efficiency improvement, remove units
Cooling system	Replace, tuneup—specify efficiency improvement, remove units
Domestic hot water	Replace heaters, reduce flows, controls / scheduling

Version 2 will add more complicated measures and coverage

Multifamily Energy Models and Calculation Engine

- Weatherization Assistant and Home Energy Saver (HES) GUIs
  - Use same multifamily energy models on the Home Energy Saver backend (API)
- New HES backend models: DOE-2.1e primary, Domestic Hot Water and Appliance
- Full DOE-2 and HES outputs will be available.
  - Multiple end-uses will be "metered" as part of the simulation results
- The Home Energy Saver MF (API) calculation engine will be available to marketplace, license fee for some
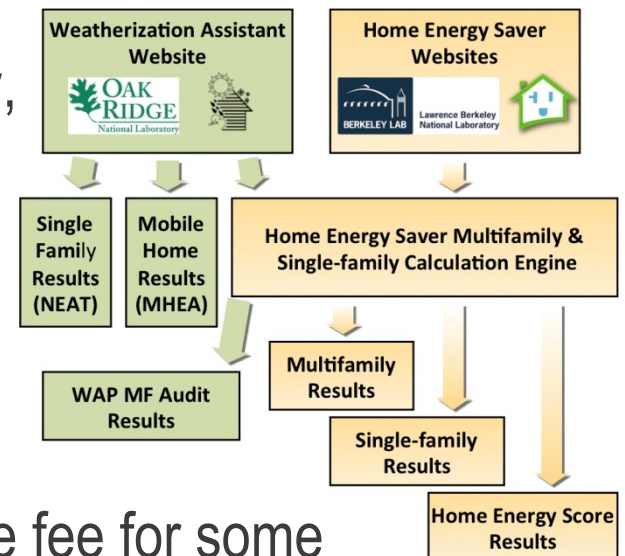
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Existing Home Energy Saver Tool Suite

Home Energy Saver - Consumer

http://hes.lbl.gov

Home Energy Saver - Pro

http://hespro.lbl.gov

Home Energy Scoring Tool

http://homeenergyscore.lbl.gov

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Home Energy Saver in a Nutshell

- Developed at LBNL. Sponsors: DOE, EPA, HUD/PATH, CEC, California Air Resources Board, Touchstone Energy Cooperatives, Infosys

- Web-based hourly simulation: DOE-2 (single-zone) and other models (LBNL, EPRI, NREL).

- Rapidly computes a home's energy consumption (all end uses), cost, and carbon footprint for any USA location and Benchmarks to regionally typical homes.

- Hundreds of possible "asset" and "operational" inputs, with smart defaults available for each home description question.

- Generates a list of payback-ranked energy-saving recommendations.

- Provides extensive decision-support information to help users implement the recommendations. Linked to social media environments.

- Transparently documented – no "black boxes"

- ~ 1 million web visits each year

- Third-party developers creating derivative tools via web service APIs for desktop & mobile applications

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What is an API?

A Familiar API....

Existing HES API Users

Home Energy Saver:
Consumer I Pro I Scoring Tool
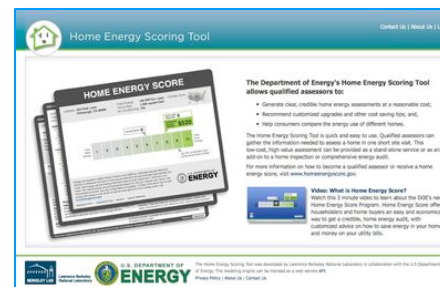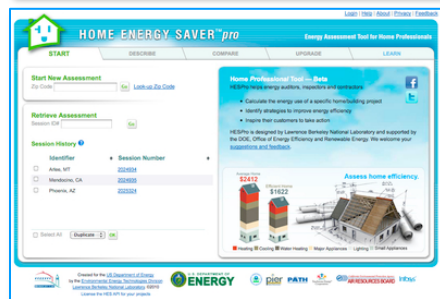
Microsoft Hohm
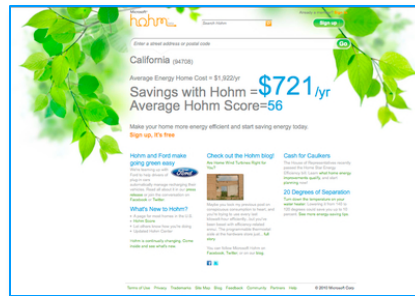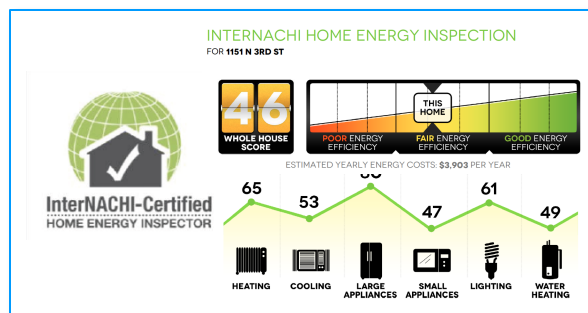
Cool California: CARB

iViro (iPhone)

Wattzon

InterNACHI

MNCEE: mobile Scoring
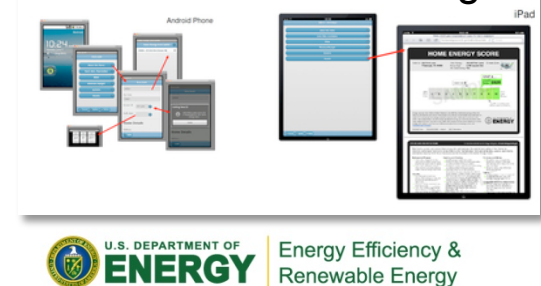
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Multifamily Tools Development Staging

- Based on the assessment of needs, input from experts across the country, and Weatherization program requirements, the WAP multifamily energy audit tool is planned to be developed in two stages:

  - **Version 1 (testing signup January 2012)**, will handle buildings with simpler system configurations, mostly low-rise buildings

  - **Version 2 (testing signup Fall 2012)** will be developed in a second stage and will increase the energy calculation capabilities to handle taller building configurations, more complex building systems, and more complex measures

  - The Home Energy Saver will be upgraded in parallel

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New Modeling Approaches

- Multiple Thermal Zones, adaptive coding approach to generalize most/all geometries

- Simplified Building Typologies, balance simplification of input with complexity of buildings

- Multiple Systems

- Utility Bill Reconciliation as first step, auditor driven, simplified in Version 1

- DOE-2.1e calculation engine, with specialized models as needed

- Integration with rules-based (stipulated) methods planned
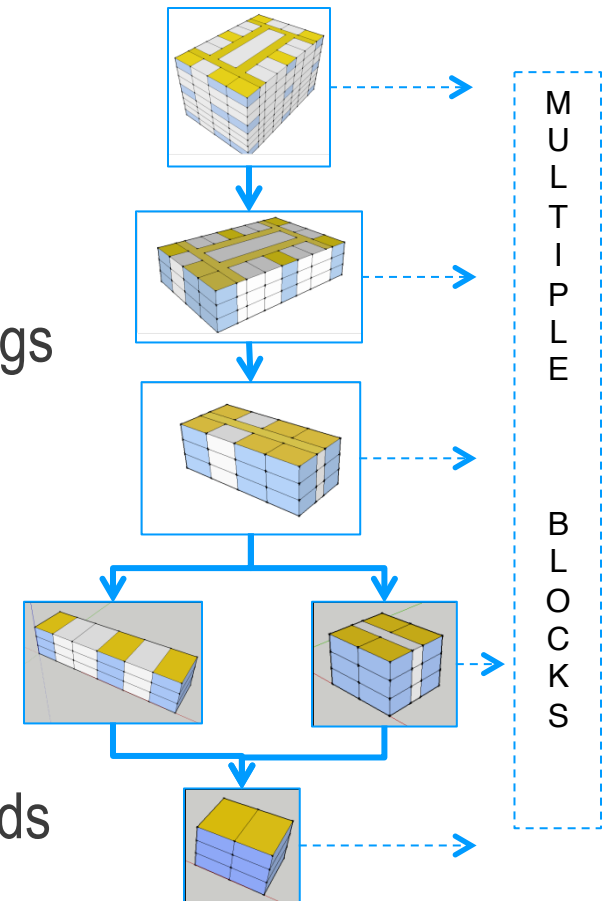
MULTIPLE BLOCKS

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New Modeling Approaches

- Multiple Thermal Zones and Building Geometry Adaptation by using:

  - DOE-2 coordinate system

  - Macros and repetitive blocks of DOE-2 code for scaling spaces, surfaces, and systems as needed (needs to scale up for Version 2)

  - Multipliers for similar zones and floors

  - Selective blocks of DOE-2 code for some types of common areas

  - Error checking to verify consistency of input
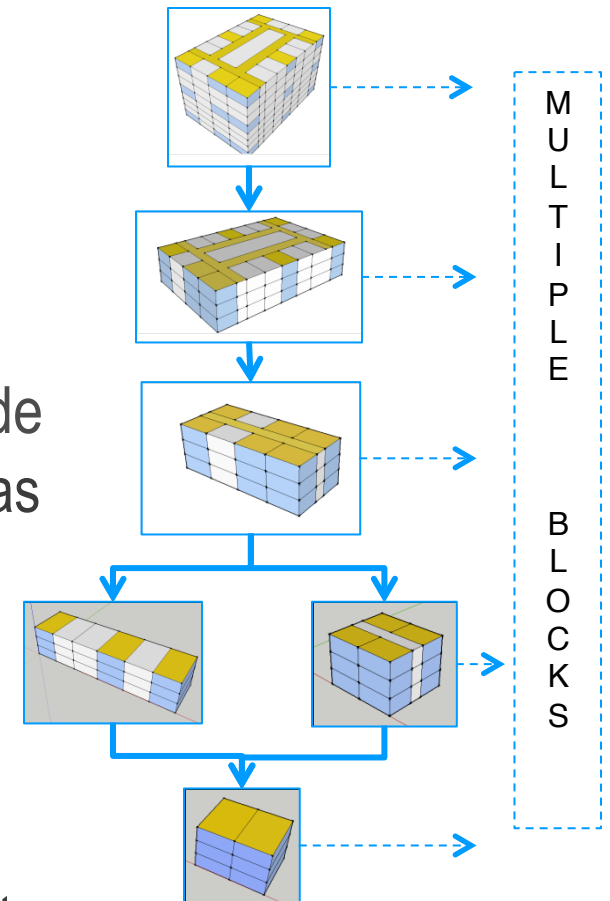
MULTIPLE BLOCKS

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Weatherization Assistant V1 and V2

- Version 1 - simpler buildings & systems, few extras
  - Low-rise, up to four floors, separate treatment of corner and interior units, first and top floors
  - Individual dwelling unit space conditioning systems
  - Both dwelling unit and central-plant domestic hot water systems

- Version 2 - more complex buildings & systems, additional capabilities
  - High-rise with service core (elevators, etc.)
  - Central plant with built-up space conditioning systems
  - More complex measures, rules-based savings
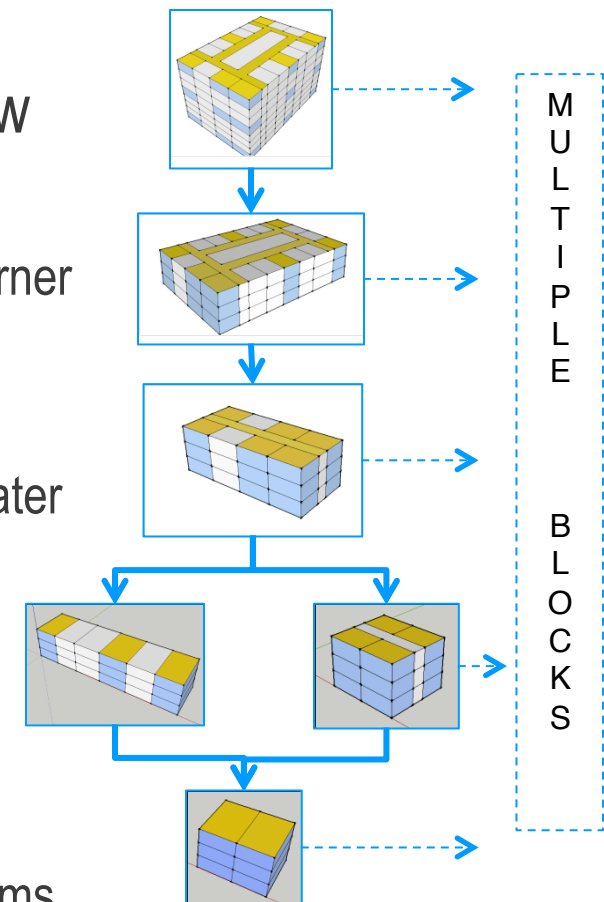
M U L T I P L E   B L O C K S

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Home Energy Saver Integration

- Existing HES methods and supplementary analyses will extend to MF (full set of end uses, carbon emissions, economics, etc.)

- HES Consumer and Pro will support assessment of individual units (tenant perspective) as well as facility-level (owner perspective), outside the formal WAP framework

- HES infrastructure (models, cloud computing, database) will support WAP tool as well

- Third-party software developers can use the HES MF APIs to incorporate the same functionality into their own software tools

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Major Components Developed for the Multifamily Tool

- New web service to provide a user interface for WAP energy auditors, agencies, and others to a web-based Weatherization Assistant

- Major Weatherization Assistant back-end applications to handle energy audit, agency, client, state, and other data and data interactions

- New web service interface for multifamily building energy audits within the Weatherization Assistant

- Major new HES back end applications (layers) to handle multifamily energy calculations and interfaces to different clients

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Major Components Developed for the Multifamily Tool

- Extensive macro templates of DOE-2.1e code required to handle multiple building and system configurations, including retrofit measures

- Domestic Hot Water models for both single unit and central system types

    - Individual unit systems: Based on the existing Home Energy Saver model

    - Central plant based systems with recirculation loops: A generic non-California specific version built from the multifamily DHW model documented in *Draft Measure Information Template – Water and Space Heating ACM Improvement,* 2013 California Codes And Standards Enhancement Initiative report, May 24, 2011 Public Workshop. ("2013 CASE Space and Water Heating 051911.pdf", PG&E, SCE, SDGE, Sempra. Download at www.energy.ca.gov)

- Major new application interface for the HES web service to handle the new multifamily DOE-2 and other specialized models (e.g., DHW, Appliances)

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Major Components Developed for the Multifamily Tool

Central plant DHW systems with recirculation loops
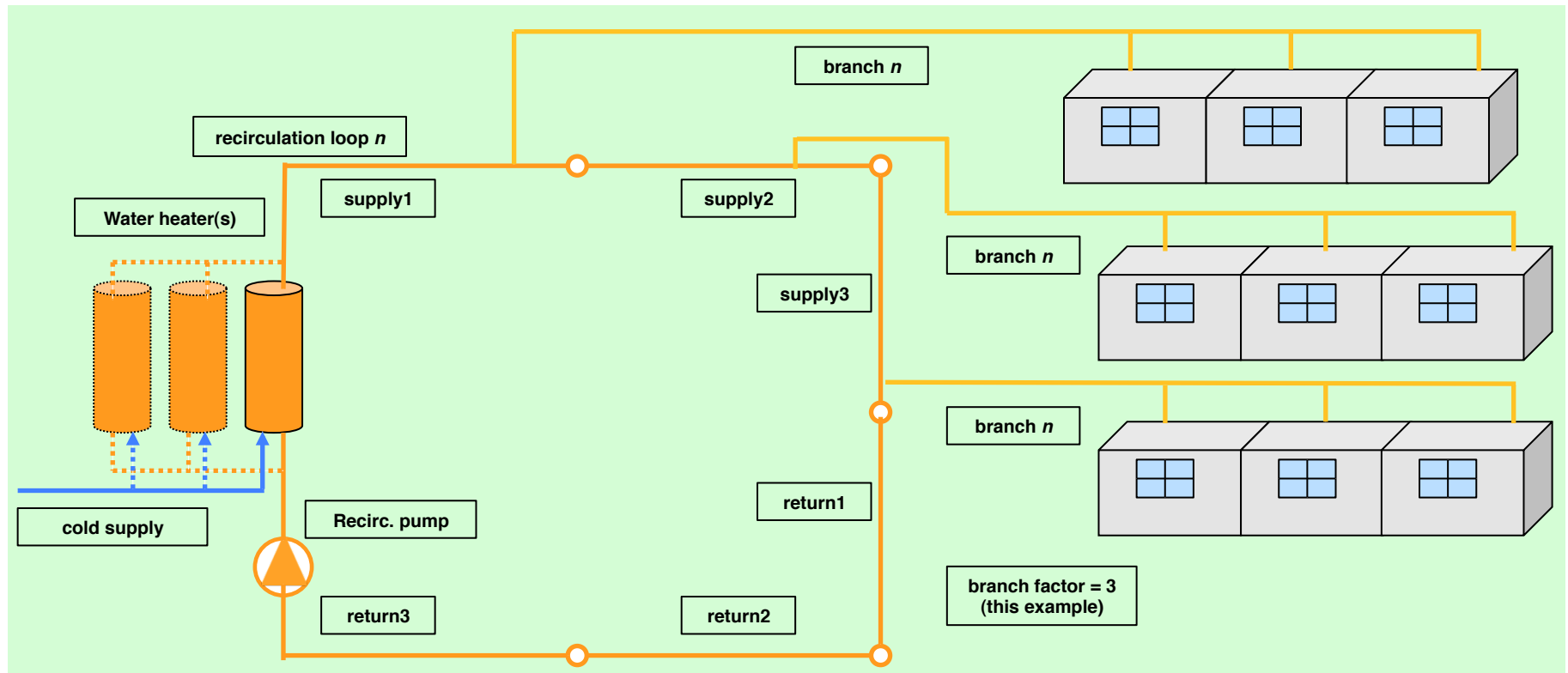
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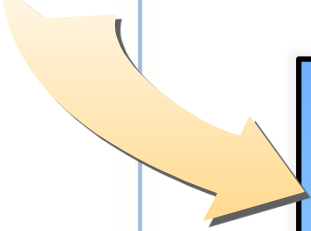
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Weatherization Assistant ▾   Agency ▾   Client ▾   Audit ▾   User ▾   Options ▾   Help ▾   Welcome Msg   Logout

Weatherization Assistant: select tool
Agency: select/add agency if needed
Client: select client or add
Audit: view, edit, or start audit
User
Options
Help

Agency and/or State Appearance Go Here

Weatherization Assistant Main Web Page

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User Interface: Building Characteristics

User Interface:
HVAC Systems

- Simpler systems only, in dwelling unit
- Efficiency type is specified
- Tune-up improvements use specified changes to be expected

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DHW User Interface

Version 1
- Baseline validation with pilot testing
- Rudimentary retrofit measures
- Limited custom user inputs (sys design)
- Fixed typical dwelling unit occupant load (RECS 2009)

Version 2
- Custom user inputs
  - Fixture flow rates
  - Custom occupant load
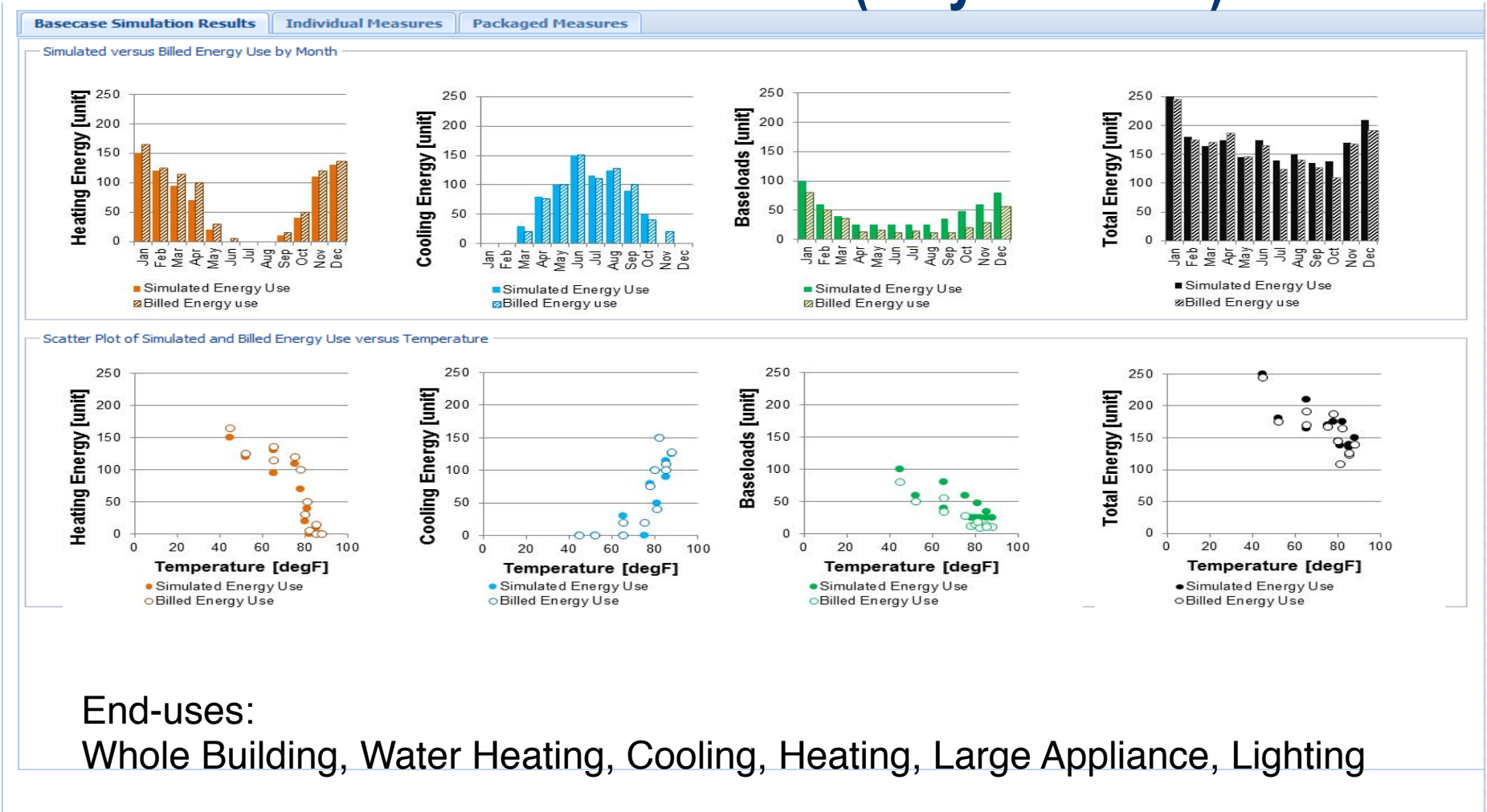- Multiple recirc. Loops
- Distribution control retrofits

Base Case Simulation Results (very tentative)

End-uses:
Whole Building, Water Heating, Cooling, Heating, Large Appliance, Lighting

Basecase Simulation Results	Individual Measures	Packaged Measures

Annual Energy and Cost Savings

Annual Energy and Cost Savings (for Measures Implemented Individually)

Index	Measure	Components (componentCode)	Annual Energy Savings [MMBtu]				Annual Energy Cost Savings [$]			
			Heating	Cooling	Baseloads	Total	Heating	Cooling	Baseloads	Total
1	Infiltration Reduction	Bldg1	8.5	2.5		11.0	83	36		119
2	Replace Heating System(s)	HtgSys1, HtgSys2	174			174	1300			1300
3	Add Storm Windows	Win1, Win2, Win4	42	4.6		49	315	140		455

Energy Savings Measure Economics

Energy Savings Measure Economics

Include in Package:	Index	Measures	Components (componentCode)	Measure Cost [$]	Individual SIR	Buy-down Amount [$]	
						Minimum Required	Available
[X]	1	Infiltration Reduction	Bldg1	1,800	1.15	0	0
[X]	2	Replace Heating System(s)	HtgSys1, HtgSys2	24,000	1.09	0	0
[X]	3	Add Storm Windows	Win1, Win2, Win4	20,000	0.45	14,800	15,000

Individual Measure Results

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Basecase Simulation Results	Individual Measures	Packaged Measures

Annual Energy and Cost Savings

Revised Annual Energy and Cost Savings (for Measures Implemented in the Package)

Index	Measure	Components (componentCode)	Revised Annual Energy Savings [MMBtu]				Revised Annual Energy Cost Savings [$]			
			Heating	Cooling	Baseloads	Total	Heating	Cooling	Baseloads	Total
1	Infiltration Reduction	Bldg1	8.5	2.5		11.0	83	36		119
2	Replace Heating System(s)	HtgSys1, HtgSys2	174			174	1300			1300
3	Add Storm Windows	Win1, Win2, Win4	42	4.6		49	315	140		455

Energy Savings Measure Economics

Revised Energy Savings Measure Economics (for Measures Implemented in the Package)

Include in Work Order:	Index	Measures	Components (componentCode)	Cost		SIR	
				Measure Cost [$]	Cumulative Cost [$]	Revised Measure SIR	Cumulative SIR
x	1	Infiltration Reduction	Bldg1	1,800	1,800	1.15	1.15
x	2	Replace Heating System(s)	HtgSys1, HtgSys2	24,000	25,800	1.09	1.11
x	3	Add Storm Windows	Win1, Win2, Win4	5,000	30,800	1.0	1.05

Measure Package Results

Pilot Testing

- User representatives invited to "kick the tires" and provide feedback

- Version 1 Pilot testing signup begins January 2012

- Participate in Pilot testing - send email to:

    - Mark Ternes, ternesmp@ornl.gov

- Other ways to provide input

    - Participate in Technical Advisory Group - send email to:

        - Norm Bourassa, NJBourassa@lbl.gov

    - Join the Multifamily Tools discussion group on the homeenergypros.lbl.gov social network

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Thank you

Jennifer Somers, US Department Of Energy (DOE)
Jennifer.Somers@ee.doe.gov

Mini Malhotra, Oak Ridge National Laboratory (ORNL)
malhotram@ornl.gov

Mike MacDonald, for Oak Ridge National Laboratory (ORNL)
mike.macdonald@epminst.us

Norm Bourassa, Lawrence Berkeley National Laboratory (LBNL)
njbourassa@lbl.gov

Evan Mills, Lawrence Berkeley National Laboratory (LBNL)
emills@lbl.gov

New tool will launch here http://weatherization.ornl.gov
APIs: http://hes.3scale.net

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Extras

Why is this needed?

Quality Work = Sustainability

- Consistency and guidelines for quality will create a stable market for the Home Performance Industry
  - Consumers and Industry Stakeholders can have confidence that there is a baseline standard for quality in the work and the workforce.
  - This confidence comes in large part from the knowledge that these guidelines are supported by a program with 30 year legacy that can provide consistent leadership in maintaining and updating these resources.